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OUTBREAK OF GASTROENTERITIS AND TYPHOID FEVER CAUSED BY POLLUTION OF PUBLIC WATER SUPPLY AT SCHENECTADY, N. Y.[1]

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In the spring of 1920 the engineering division of the New York State Department of Health was called upon to investigate an epidemic of gastroenteritis, followed by an outbreak of typhoid fever, in the city of Schenectady, N. Y., which occurred subsequently to the gross pollution of the public water supply of the city by the water of the Mohawk River. The results of the investigation, as outlined below, are interesting because of the clearly defined manner in which the effects follow the cause, and also because they illustrate how easily the trouble could have been avoided by the careful supervision of the waterworks and how the effects might have been mitigated had the first warnings been heeded.[2]

The matter was first brought to the attention of the Division of Sanitary Engineering on March 20, 1920, when information was received that on March 15 and a few days following, the number of cases of gastroenteric disturbances in the city had greatly increased above the number normally occurring; and that this increase had followed a noticeable turbidity in the water, which had been greatest on the night of March 13 and during March 14 and had gradually disappeared after the latter date. Although the information was not received until several days after the incidence of the largest number of cases, an engineer from the engineering division was at once sent to investigate the condition of the water supply to determine whether or not it had been, or was, such as would be likely to cause the disturbances reported. On the date of the first inspection, March 20, 1920, the water was clear and colorless, and it was

[1] A résumé of reports made by the author to the New York State Department of Health.

[2] EDITORIAL NOTE.—In a brief article in Public Health Reports for January 30, 1920, entitled "Water-Borne Typhoid and Spring Freshets," attention was called to the necessity for exercising especial care in safeguarding water supplies during the winter and early spring months, and numerous instances were cited of outbreaks of typhoid fever during these seasons. In that article it was stated: "So far as water-borne typhoid infection is concerned, now is the time for health officers to be especially alert. Many of the well-known extensive water-borne epidemics of typhoid fever have occurred during the winter and early spring, being associated in the majority of instances with extensive rains and freshets which washed infected material into the water supply."

The present account of the outbreak at Schenectady, N. Y., teaches a very valuable lesson in this problem and adds an additional note of warning to all health officers to be on guard for potentially dangerous water supplies.

therefore necessary to depend largely on what could be learned from the officials and residents of the city for information regarding its alleged unsatisfactory condition. Most of the residents interviewed confirmed the statement above regarding the marked turbidity of the water and the gastroenteric disturbances which followed. The city officials stated that so far as they knew the turbidity was not very noticeable, and that it consisted of fine sand in the water, owing probably to the disturbed condition of the ground water flow caused by the recent thaws and the high water in the river. They also stated that the city chemist and the city bacteriologist had both recently examined the water and reported that it was perfectly safe for consumption without treatment. At the plant, little could be learned except that the water had risen very high in the wells on the 13th and 14th of the month. The man in charge of the plant stated that he had noticed a little turbidity in the water, but that he had not thought it of any importance and could not remember on exactly which dates it had occurred. He insisted that the turbidity had been due to the low vacuum on the pump suctions and the higher pumping rate. This rate, however, was estimated to be only about 10 per cent above the average.

Samples of the water for bacterial and chemical examination were taken at several points by the department engineer and carried immediately to the laboratory for examination. At the end of one day, inoculations for the determination of the presence of *B. coli* indicated the probability of the presence of those organisms in all the samples, and in as small a quantity as $\frac{1}{10}$ c. c. in one sample. It was also noted that the chlorine content of the chemical sample was about twice that of the content of the samples previously taken. These results, together with the fact that the explanation given by the attendant in charge of the waterworks as to the reason for the turbidity in the water, seemed inadequate to the engineer making the investigation, made it appear advisable that a thorough inspection of the plant and wells should be made. This inspection was made on March 24. The results of the examination can be clearly explained only by a detailed description of the arrangement of the pumping station, the wells, and the connecting pipes.

The water supply of the city of Schenectady is obtained from three dug wells at the waterworks pumping station, located about $2\frac{1}{2}$ miles west of the city on a flat piece of land lying between the south bank of the Mohawk River and the hills which rise abruptly from the plain about 1,000 feet south of the river. Wash borings made a short time before the investigation indicate that the soil in the vicinity of the waterworks consists of clayey loam from the surface to a depth of 12 feet, the lower 2 feet containing considerable gravel; from a depth of 12 feet to the depth of 60 feet, a sharp coarse sand mixed with gravel containing a considerable proportion of stones

several inches across; and below 60 feet, an impervious clay. Whereas the surface of the ground is practically level, the surface of the impervious stratum beneath the gravel appears to slope gently toward the wells from three directions and away from the wells or toward the river, in the fourth, or northerly direction. The wells extend through the upper 12 feet of loam into the gravel stratum from which they receive their water. They are arranged in a line parallel to the river and about 400 feet from it. A highway leading into Schenectady, and the Erie Canal, both parallel to the Mohawk River, lie between the wells and the river, the canal being the nearer to the stream.

Well No. 1, the oldest and most westerly of the three, is 60 feet long, 8 feet wide, and about 42 feet deep. The walls, of masonry and of considerable thickness, are built of large cut stones, the lower courses apparently having been laid without mortar. The roof is formed by a well-constructed arch about 22 feet below the surface of the ground. Near the center, a short section of the well extends to a point within a few feet of the surface of the ground, and a manhole in the roof of this section gives access to the well for inspection. The bottom of the well is the gravel encountered at that depth when the well was dug. At the time of the inspection the water in the well was clear and colorless. The walls and roof of the central section were wet, but there were apparently no material leaks. The places where the old suctions, described below, from the pump house to the river, had passed through the walls of the well were visible, but the patches which closed the openings originally occupied by the pipes were apparently tight. Open joints between the stones forming the walls of the well were clearly visible below the water line.

Wells No. 2 and No. 3 are circular in form, 42 feet in diameter, and about 40 feet deep. The walls are of concrete, and the roofs are apparently made of reinforced concrete supported on steel beams which span from the walls to the Phoenix columns set in the centers of the wells. As in the case of well No. 1, the bottoms are formed by the natural gravel. These two wells were, at the time of the inspection, in an entirely satisfactory condition. The three wells are connected by cast-iron siphons said to be 16 inches in diameter, one between well No. 1 and well No. 2, and the other between well No. 2 and well No. 3, arranged to allow the water to flow from one well to the other. The pump suctions connect to wells No. 1 and No. 2. As near as could be learned from the available records the level of the water in the wells, with the pumps running, is usually about 210 feet above mean tide, and that in the river is 2 feet higher, or about 212 feet above mean tide. At times, however, the water rises as much as 20 feet above these levels.

The pumping station stands about 30 feet south of well No. 1 and at the time of the investigation housed three motor-driven vertical two-stage centrifugal pumps which lift the water from the wells and discharge it into the city mains and the 20,000,000-gallon storage reservoir. The suctions of these pumps connect to a 36-inch header, the west end of which extends into well No. 1 and the east end into well No. 2. Apparently the valves on the suction lines are generally left open so that the pumps draw from both well No. 1 and well No. 2. The water from well No. 3 can only reach the suction pipes by first passing through the siphon from that well to well No. 2.

Originally, the pump house now in use contained two large steam-driven reciprocating pumps which were connected to well No. 1 and were also provided with two 24-inch suctions extending to the Mohawk River. These two suctions passed out through the wall of the basement of the pump house about 18 feet below the surface of the ground, extended through two converging pipe galleries to well No. 1, crossed through the raised central section of that well, mentioned above, and continued in two parallel pipe galleries to a manhole at the road about 30 feet north of the well. From this point the pipes extended through the ground without galleries to the river. The galleries are about 6 feet across and 8 feet high. The walls and arched roofs are constructed of brick. The galleries are not paved, the bottom being formed by the gravel encountered in excavating them. Two manholes, one on the south side of well No. 1 and the other at the side of the road about 30 feet north of the well, afford access to the galleries. The suction pipes had been removed from the galleries, and the holes through the walls of the well and through the wall of the basement of the pump house had been sealed with concrete and brick. The portions of the pipes from the gallery to the river still remained in place. One of these pipes, the westerly one, was sealed with concrete. The other pipe, the easterly one, was apparently open from the river to the gallery.

The existence of these galleries and the fact that they could be reached by manholes, the covers of which were made visible by the melting of the snow, became known to the engineers from the Division of Sanitary Engineering of the State Department of Health on March 24, and they were immediately inspected. The galleries between the well and the road had apparently been full of water carrying considerable suspended matter a short time previous to the inspection. The bottoms were covered with a slimy deposit of black silt to a depth of from one-half inch to 2 inches, and the upper surfaces of all projections of the brick work to a height of about 8 feet above the bottom of the gallery were likewise covered with a deposit of the same material, the quantity of deposit being less on the higher projections. The deposit of

sediment was practically uniform over the bottom of the galleries, except at points in both galleries about 10 feet from the north wall of the well. Here, in each gallery, there were several holes from 6 to 10 inches across on the top and extending from 1 foot to 2 feet down into the gravel in which the stones were perfectly clean, as if a swift stream had passed down through the coarse gravel at these points and carried with it all the silt and fine material. The general arrange-

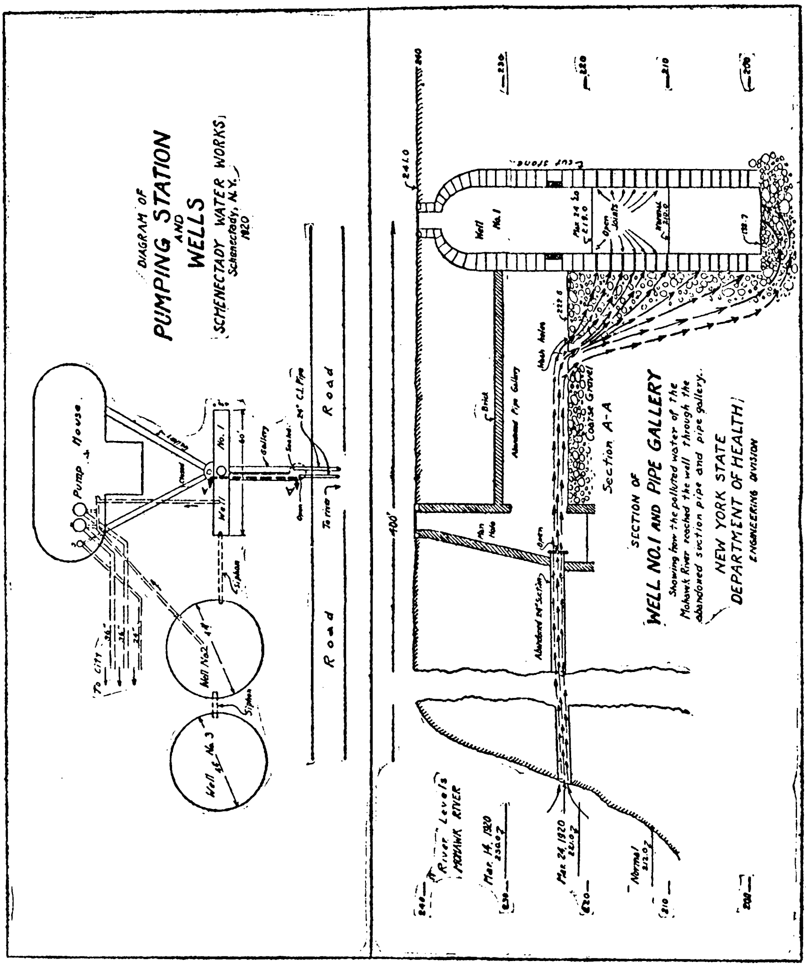

FIG. 1.

ment of the wells and pumping station, together with a section through the galleries and suction lines, giving the relative elevation of the galleries and the water in the river and wells at different times, is shown in the accompanying drawing. (Fig. 1.)

The elevation of the bottom of the galleries is approximately 222.5 feet above mean sea level, or about 10.5 feet above the normal river level. An examination of the records of the river elevations kept by the lock tender at Barge Canal Lock No. 8, about a quarter

of a mile west of the pumping station, revealed the fact that the river had risen from an elevation of about 214 feet at noon on March 13 to 228 feet at midnight on that date, over one-half of the rise, 9 feet, occurring between 2 and 3 o'clock. The river reached its maximum elevation of about 230 feet at 4 p. m. on March 14; and after that time the elevation gradually fell, reaching 224 feet on the 20th and 222 feet on the 21st of the month. The elevation of the water in the wells, figured from the record of the vacuum on the pump suctions, rose more slowly than that of the water in the river, the maximum rate of the rise being about 1 foot per hour. The river elevation was, therefore, for a considerable time, several feet above the elevation of the water in the wells. On the afternoon of the 13th this difference varied from 6 feet at noon to about 14½ feet feet at 3 p. m., dropping again to 7 feet at midnight. During the entire day of the 14th the elevation of the river was a little over 6 feet above the elevation of the water in the wells, and from that date on gradually decreased, the difference on the 20th being only about 9 inches.

Compared with the elevation of the bottom of the pipe gallery, these figures indicate that the river surface was above the floor of the gallery from 3 o'clock on the afternoon of March 13 until March 20, and that during the afternoon of the 13th and during the 14th the river surface was between 6 and 8 feet above the bottom of the gallery while the water in the well remained below the bottom of the gallery.

Apparently, therefore, from the 13th to the 20th of March there was nothing to prevent the polluted water of the Mohawk River from flowing from the river to the galleries through the open 24-inch suction line, then along the galleries and, as indicated above, down through the wash holes a few feet from well No. 1, and through a few feet of coarse gravel into the well either by way of the joints in the stonework or up through the open bottom. The largest rate of flow into the well by this means would, of course, have occurred on the 13th and 14th of the month, when the difference in elevation between the surface of the river and the surface of the water in the well was greatest, and would have gradually decreased as the difference in elevation became less. This is in general accordance with the evidence as to the turbidity in the city water, which is said to have been the greatest on the night of the 13th and during the 14th, gradually becoming less during the week and finally disappearing about the 19th or 20th.

The possibility of the pollution of the city water supply by the river water could have been prevented had the waterworks officials been familiar with the piping at the station, given due attention to the elevations of the river, and stopped using the water from well

No. 1 when the water of the river rose so high as to endanger the quality of the water from that well. This could have easily been done by closing a valve and breaking the seal of a siphon. Even if they had not observed the river elevation, the turbidity of the water which they noticed should have warned them that some unsatisfactory condition existed which they should have taken immediate steps to correct.

The open suction line and the probability of its being the cause of gross pollution of the water was at once pointed out to the superintendent of water of the city, and he immediately had the open pipe sealed. A report on the conditions was sent to the city authorities

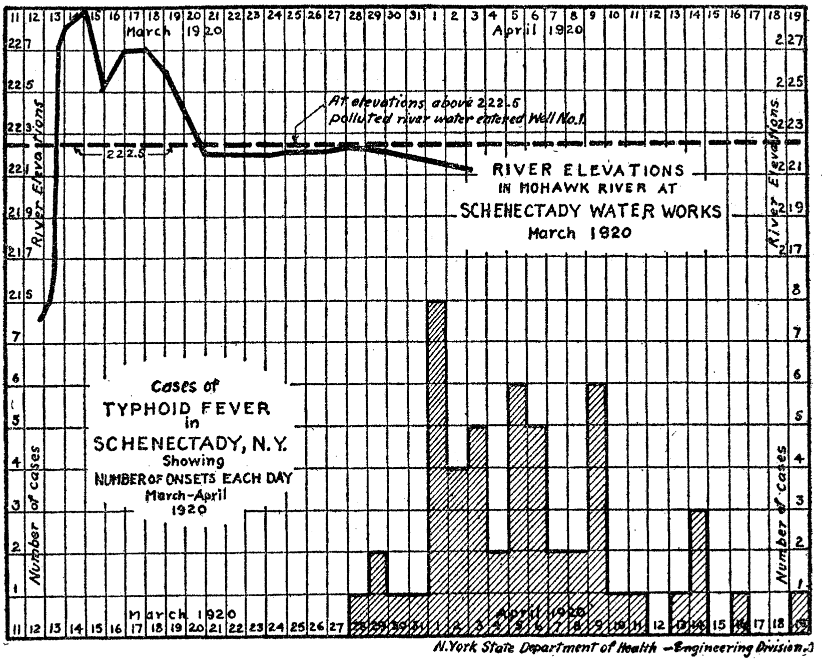

FIG. 2.

shortly afterwards, in which it was recommended that the possibility of further pollution of the water from this source be prevented by the removal of part of the suctions between the well and the river. This recommendation was also carried out by the city authorities. The removal of the possibility of further pollution did not, of course, prevent the damage done by the gross pollution and infection of the water between March 13 and March 19. An epidemic of gastroenteritis disturbances occurred on March 15 and lasted for several days. On March 28, 15 days after the first pollution of the water, or 10 days after the day on which the inflow of polluted water into the river ceased, one case of typhoid was reported. Others followed. On April 1 the onsets of eight cases occurred, and for the

next week the number of onsets ranged from two to six, the number gradually decreasing. The last case was reported as occurring on the 19th. In all there were 53 cases, 3 of which terminated fatally. The majority of the cases occurred about two weeks after the pollution of the well by the contaminated water of the river.

BIOLOGICAL INVESTIGATION OF CALIFORNIA RICE FIELDS RELATIVE TO MOSQUITO BREEDING.

PROGRESS REPORT.

By W. C. PURDY, Special (Plankton) Expert, United States Public Health Service.

During 1918, an investigation carried on by the writer in Arkansas[1] during the entire rice-growing season furnished the following data:

1. Anopheles mosquitoes (*A. quadrimaculatus*) breed in moderate abundance within the rice fields, as well as in ditches and puddles outside the rice fields.
2. Culex breeds in about the same numbers as Anopheles, both inside and outside the rice fields.
3. Certain enemies of mosquito larvæ (aquatic beetles and their larvæ) are about as numerous on the rice fields as mosquito larvæ themselves.
4. Top-feeding minnows (Gambusia) placed in the rice fields at the rate of 1,400 per acre constitute a check, but not a control, of mosquito production.
5. Oil-soaked sawdust sown broadcast in the rice when the plants are well grown works no injury to the crop and produces an oil film that kills practically all larvæ.

During the rice season of 1919, a similar investigation[2] was carried out in the rice-growing region of northern California. The scope of the work was extended to include (1) examination for mosquito larvæ; (2) a general survey of the larval food supply; (3) the number and kinds of larval enemies; (4) the relative abundance and kinds of algæ present; (5) adult mosquitoes. These were collected weekly from beneath a long, low, concrete bridge near an ideal breeding place.

The outstanding objects of the investigation were as follows:

1. To ascertain the comparative amount of breeding, especially of Anopheles, in the rice fields as compared with simultaneous breeding in seepage puddles, drainage ditches, or other nonrice-field water capable of being treated or the collection of which is preventable.

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[1] Under administrative authority of Assistant Epidemiologist J. C. Geiger. See Jour. Am. Med. Ass'n. Mar. 15, 1919.

[2] Planned in detail by the writer and carried out under his personal supervision. Administrative authority, J. C. Geiger, until Sept. 1; assistant in field work, L. D. Mars, until Aug. 15, 1919.